PHYTOTOXICOLOGY STUDIES IN THE VICINITY OF INTERNATIONAL MINERALS AND CHEMICALS LTD. PORT MAITLAND: 1984 - 1985

ARB-115-86-Phyto

OCTOBER, 1986

Ontario
Ministry of the Environment

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Air Resources Branch

Phytotoxicology Studies in the Vicinity of International Minerals and Chemicals Ltd. Port Maitland: 1984 and 1985

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ARB-115-86-Phyto

October, 1986

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Introduction

The Phytotoxicology Section has conducted extensive terrestrial assessment surveys around the IMC fertilizer plant in Port Maitland since 1969. The company ceased manufacturing operations in July 1985. Fertilizer is shipped up from American manufacturing sites and the Port Maitland facilities are now used as a distribution centre only. In 1984 and 1985 the investigative activities included:

1. Vegetation complaint investigations
2. Forage collections modelled after the 1975 Ministerial Control Order
3. Maple foliage collections from an established network of sampling sites
4. Examination of indigenous and ornamental fluoride-sensitive plant species for evidence of air pollution injury
5. Soil sample collection to determine the severity and extent of fluoride and uranium deposition.

Assessment activities were continued in 1985 to obtain data during a non-operational growing season. This data would be useful in the event that manufacturing of fertilizer products is resumed.

Vegetation Complaint Investigations

In 1984, Phytotoxicology field officers conducted two vegetation complaint investigations on behalf of Port Maitland area residents. Emissions from IMC were not responsible for the problems observed on either of these properties.

In mid-summer 1984, IMC ceased manufacturing phosphate fertilizers at its Port Maitland plant. Therefore, stack emissions of fluoride (F) also ceased in the middle of the 1984 growing season. Although manufacturing was suspended, IMC fertilizers are shipped up from American factories by rail and distributed from the Port Maitland site. Therefore, fugitive, F laden, dust emissions may still originate from this operation. In addition, the settling ponds are being maintained, and they also are a potential source of fugitive F emissions. Phytotoxicology studies continued in 1985 to assess post-manufacturing fugitive emissions.

No vegetation complaints were received in 1985, although one request was made by a resident living immediately downwind of IMC to have soil and forage samples collected to determine if the land was suitable for agricultural purposes. No residual contamination was discovered and the resident was informed that there were no apparent restrictions for agricultural land use.

Forage Collections

In 1975, IMC was placed under a Ministerial Control Order which permitted the company to produce superphosphate fertilizer during the growing season provided F levels in forage with 3000 m of the source did not exceed a series of established criteria. IMC performed responsibly and the control order was officially suspended in 1980. However, forage monitoring was continued along the control order format to provide a continuous F in forage data base as a safeguard for local cattle producers.

In 1984 and 1985, forage was collected monthly from April to October, inclusive, from nine collection sites (Figure 1). The forage samples were processed not-washed, as they would be consumed by cattle. Table 1 summarizes the analytical results for the 1984 forage collections. No single monthly collection exceeded the 80 ppm criterion, and similarly, none of the nine sampling locations

averaged more than 35 ppm for the duration of the growing season. In addition, the 60 ppm criterion was not exceeded at any site for two consecutive monthly samples (Table 2). The highest F concentration detected in forage in 1984 was 40 ppm at Site 4 in the Village of Stromness, approximately 2300 m E of IMC. Forage F levels were lowest at the beginning and end of the growing season, averaging 8 ppm (mean all 9 sites) in both April and October, and highest in mid-summer (13 ppm F in July).

1985 was the first growing season with no manufacturing emissions. F concentrations were lower in 1985 than 1984 at almost every site for each collection. A noticeable exception was the September collection when forage at Site 11 contained 26 ppm F. In 1984 during the same month, the F concentration at the same site was only 5 ppm. Although this single collection was unusually elevated it was not a potential risk for cattle because the 80/60/35 criteria were not exceeded. In fact, the seasonal mean F concentration at Site 11 in 1985 was only 9 ppm. The 1984 forage data are summarized in Tables 3 and 4.

The trend toward increasing F levels in forage towards the middle of the growing season followed by a gradual decrease into the fall, did not occur in 1985. Figure 2 illustrates the mean F concentration of the nine sites for each of the 7 monthly collections in 1984 and 1985. It clearly shows that the 1985 levels are substantially lower and that the seasonal accumulation trend did not occur.--Figure 3 illustrates the seasonal mean F concentration for common forage sites collected since 1975. Fluoride levels have fallen annually since 1982, and, as expected, the concentrations in 1985 were the lowest in the eleven consecutive years of sampling. The highest annual mean concentration was 35 ppm, which occurred in 1977. In 1984 it fell to 10 ppm, then to 5 ppm in 1985.

Figure 4 illustrates the relationship between the F levels in forage at collection Sites 1 and 4. Previous to the construction of the D1 and D2 settling ponds Site 1, to the NE of IMC, always had substantially higher F levels than Site 4, situated to the E of the source. After the new settling ponds began operation in about 1980, the F levels in forage from the eastern location (Site 4) increased dramatically. After the large C pond was capped, in about 1982, the F concentrations at Site 1 declined substantially. These data reveal that settling ponds are significant F sources, although the extent of contamination tends to be much more localized than stack emissions.

In summary, there were no violations of the former Ministerial control order criteria in 1984 or 1985 (see Table 5). The F levels in forage in 1985 were the lowest since regular forage sampling was initiated in 1975. Figure 5 is a map of the Port Maitland area illustrating the 1984/85 mean growing season F concentrations in forage from the nine collection sites.

Maple Foliage Assessment Survey

Maple foliage was collected from 30 locations in early September in both 1984 and 1985. The sample sites are illustrated in Figure 6. The foliar samples were collected in replicate from the lower 1/3 of the tree crowns on the sides facing the direction of IMC. The samples were processed not-washed and analyzed for total F and uranium (U).

The mean F concentration of unwashed maple foliage from all 30 collection sites was 19 ppm in 1984 and 10 ppm in 1985. In 1984, IMC was only in operation for about one half of the growing season. No manufacturing took place in 1985. Figure 7 illustrates that the F levels in foliage in the last two years were the lowest since collections were initiated in 1970. In 1984, the maximum foliar F level occured at sample Site 17, 0.5 km E of IMC. The F concentration at this site was 67 ppm. Sample Site 26, 0.6 km S of the source, had the highest F level in 1985, which was 26 ppm. By comparison, foliar F concentrations have exceeded 400 ppm at these two sites in 1982 and 1983 and over 1000 ppm in previous years.

Table 6 summarizes the F maple foliage data for 1984 and 1985. The previous two years are also included for comparative purposes. The Phytotoxicology Upper Limit of Normal guideline does not imply an injurious F concentration. This level is the product of a statistical formula designed to incorporate the intrinsic F concentration of 99% of the background or control population (Mean x 3 standard deviations). When levels of F in maple tree foliage exceed 35 ppm the investigator can confidently state that an extraneous source is involved. Maple foliage at 12 of the 30 sites had F levels greater than the Phytotoxicology guideline of 35 ppm in 1982 and at 15 sites in 1983. By comparison, in 1984 only 4 sites had foliar F levels above the 35 ppm criterion and no sites exceeded the criterion in 1985.

The phosphatic rock which IMC imported from Florida to manufacture fertilizer contained between 1% and 4% F and approximately 0.0125% U by weight.

Although F in maple foliage has been monitored around IMC since 1970, U analysis was initiated only in 1981. As with F, a clear gradient of U contamination was evident relative to distance and direction from IMC. However, whereas F concentrations in the past were often very high, the U foliar levels from the same sites were only marginally elevated. The U concentrations of maple foliage in the vicinity of IMC rarely exceeded the 0.6 to 0.8 ppm range detected by limited control sampling for this element.

Table 7 summarizes the U foliar concentrations at the 30 maple collection sites from 1981 to 1985. The mean U concentrations in 1981, 1982 and 1983 were 0.09 ppm, 0.10 ppm and 0.12 ppm, respectively. In 1984 U foliar concentrations were below the analytical detection limit of 0.05 ppm at all 30 collection sites. In 1985, U was detected at only 5 sites, of which 4 were well within the natural range of this element in woody vegetation. The one elevated concentration occurred at Site 35, 1.9 km SW of IMC where foliar U levels averaged 0.95 ppm. Even though this level is marginally higher than control/background samples collected to date it is of no environmental consequence. In addition, these anomalous results occurred upwind of a non-operative source.

The 1984 and 1985 F and U foliage data were displayed as contaminant gradient maps using the computer SYMAP program. SYMAP, an acronym for synigraphic computer mapping, was developed by Harvard University. The SYMAP program produces maps which illustrate spacially-arrayed data in pre-chosen value ranges. The program contours the data, defined as each datum point, by comparing each empty point with the nearest seven data points weighted according to the inverse of the square of the distance to each and includes a directional bias. Detailed, objective gradient maps can be constructed with a minimum of speculative interpretation.

Figures 8, 9 and 10 are SYMAPS of F in maple foliage around IMC in 1983, 1984 and 1985 respectively. The 1983 map was reproduced from an earlier Phytotoxicology report and is included here for comparative purposes. The pre-chosen value ranges were: 1) less than 35 ppm, 2) 35-49 ppm, 3) 50-99 ppm, 4) 100-150 ppm and 5) greater than 150 ppm. The 1983 SYMAP illustrates that in 1983 IMC was a significant source of F contamination in the Port Maitland area. In 1984 both the severity and extent of contamination were reduced substantially such that elevated F levels occurred only in the immediate vicinity of the IMC manufacturing

complex. The 1985 SYMAP (Figure 10) shows no pattern of contamination at the chosen value ranges indicating that no collection sites significantly exceeded the normal background range of F in tree foliage.

However, in both 1984 and 1985 there was a clear gradient of foliar F concentrations relative to IMC, even though the F levels were not significantly elevated, particularly in 1985. This F gradient can be illustrated by altering the SYMAP value ranges, thereby making the program more sensitive to much smaller increments of foliar F. Figures 11 (1984) and 12 (1985) are SYMAP of foliar F concentrations using the following, dramatically reduced, value ranges: 1) less than 10 ppm, 2) 10-20 ppm, 3) 21-30 ppm, 4) 31-50 ppm and 5) greater than 50 ppm. The altered 1984 SYMAP (Figure 11) clearly illustrates that the F contamination which did occur in this year was detected immediately adjacent to the IMC stack and storage den and downwind (E) of the D settling ponds. The altered 1985 SYMAP (Figure 12) reveals that foliar F contamination was localized directly adjacent to the den area where the shipped fertilizer is prepared for re-distribution. It would appear, based on these data, that in the present post-manufacturing stage, fugitive emissions associated from the handling of fertilizer products are a more significant source of ambient F than the settling ponds, although the (terrestrial) environmental consequences of both sources are negligible.

SYMAPS were also prepared for the foliar U data. Figure 13 is a SYMAP of the 1983 foliar U data prepared for a previous Phytotoxicology report and included here for comparison. The value ranges were:

1) less than 0.08 ppm;
2) 0.08 to 0.15 ppm;
3) 0.16 to 0.50 ppm; and,
4) greater than 0.50 ppm.

Figure 12 (the 1983 data) illustrates a clear, although only marginally elevated, foliar U gradient centered around the IMC stack area. A 1984 map was not prepared because all levels were less than the analytical detection limit. The 1985 foliar U data are illustrated in Figure 14. Although it would appear that slightly elevated U levels may be associated with proximity to the D settling ponds, similar and even higher U concentrations occurred at several sites upwind of IMC. The SYMAP program could not be "fine-tuned" as it was for the 1984/85 F data base

because the foliar U levels in these years were already so close to the analytical detection limit. In addition, there was a consistent and highly significant statistical correlation (P 0.001) between maple foliar U and F concentrations at the same sites in 1981, 1982 and 1983 during typical manufacturing years. During the 1985 shut-down the F and U foliar concentrations were not statistically correlated. The 1984 data base was not tested because there was no U component. This relationship suggests that F and U are emitted during the manufacture of phosphatic fertilizers but only F and not U appears to be associated with fugitive emissions from the IMC den areas and settling ponds during the post-manufacturing operations at the Port Maitland complex.

Injury to Sensitive Species of Vegetation

Many species of plants found in the Port Maitland area, both indigenous and introduced ornamental, are sensitive to F emissions. Red, silver sugar and Manitoba maple, the species collected for foliar analysis, are all F sensitive, although sugar maple is more resistant than the other three. Generally, F injury can be expected to occur within the zones indicated on the SYMAPS as 3, 4 and 5 (Figures 8, 9 and 10 only). In 1983, F injury on maple foliage was observed as far as 3.2 km NE of IMC. However, in 1984 the extent of air pollution injury on the leaves of sampled trees was substantially reduced, being observed only at two sites immediately south of the IMC manufacturing complex on Rymer Road and at one location in the area of Rymer and Downey Roads, approximately 0.5 km E of the source. No F injury symptoms were observed on maple trees in 1985.

Wild grape is ubiquitously distributed throughout the Port Maitland area and is extremely sensitive to relatively low ambient F concentrations, displaying characteristic injury symptoms. For this reason the presense of F-like injury on wild grape has been used to delineate an annual, visible effect zone. Figure 15 illustrates the extent to which F air pollution injury was observed on wild grape in 1984 and 1985. For comparative purposes the 1983 injury zone is included in this figure.

The area of wild grape injury, illustrated in Figure 15 was measured with a compensating polar planimeter. In 1983, F injury on wild grape was observed over approximately 23.6 km^2, extending about 1.5 km NE of IMC. In 1984, the area of injury was similar in shape and size, covering about 24.2 km^2. In this year, IMC was in operation until late July and the grape assessment was conducted in early

September. In 1985, injury on wild grape was only observed in two small areas, totalling approximately 1.4 km^2, one immediately S of IMC and the other along Neice Road at the NE edge of Rock Point Provincial Park. These data corroborate the maple foliage analyses which demonstrated that in a post-manufacturing phase, limited phytotoxic F emissions occurred from the area of the IMC den and the D settling ponds.

Soil Survey of Historic Fluoride and Uranium Deposition

In 1985, surface soil samples, 0-5 cm in depth, were collected in replicate from the 30 maple collection sites and analyzed for total F and U concentration. These data are summarized in Table 8. There are no upper Limit of Normal guidelines with which to compare the Port Maitland F and U soil concentrations. However, literature references and limited Phytotoxicology control sampling would suggest that background soil U levels should not exceed 2.0 ppm but that F concentrations are considerably higher and more variable, perhaps up to 300 or 400 ppm.

The highest F soil level was 523 ppm, at Site 17, 0.5 km E of IMC. The highest U concentration, 5.34 ppm, was also detected at this location. There was an indentifiable concentration gradient for both elements relative to IMC with the highest levels consistently occurring in close proximity to the manufacturing complex.

The F and U deposition patterns were illustrated with SYMAP Figures 16 (F) and 17 (U). The pre-chosen soil value ranges for F were:

1) less than 25 ppm;
2) 25 to 50 ppm;
3) 51 to 100 ppm;
4) 101 to 200 ppm; and,
5) greater than 200 ppm.

For U the value ranges were set at:

1) less than 0.2 ppm;
2) 0.2 to 0.5 ppm;

3) 0.6 to 1.0 ppm;
4) 1.1 to 2.0 ppm; and,
5) greater than 2.0 ppm.

The F and U soil concentrations from the same site were highly statistically significant; correlation coefficient r = 0.826, $P \leq 0.0001$. Similarly, the 1985 U and F soil levels were (statistically) significantly related to the U and F maple foliage concentrations back to at least 1981 (see correlation statistics, Table 9). These data confirm that the elevated levels of F and U in the soil around Port Maitland are associated with historical deposition from IMC.

Neither the F nor U concentrations detected in the 1985 soil survey represent an environmental concern. The literature suggests that the threshold for growth/yield reductions in sensitive crops for U is about 50 ppm, almost 10 times higher than the maximum U concentration and over 70 times higher than the average soil U level in the Port Maitland area. The F concentration of soil is higher and much more variable than U, although literature references to soil F concentrations suggest that the background range in heavy textured clay soils may exceed the maximum level detected in Port Maitland by a factor of 2 or 3.

Summary

In 1984 and 1985, staff from the Phytotoxicology Section conducted complaint investigations, monthly forage samples, maple foliage and soil assessment surveys and examined vegetation for air pollution injury symptoms.

Emissions from IMC were not implicated in complaint investigations conducted in Port Maitland in these two years.

Forage collected from nine sites did not exceed any of the former Ministerial Control Order criteria. Therefore, there is no risk to cattle consuming locally grown forage.

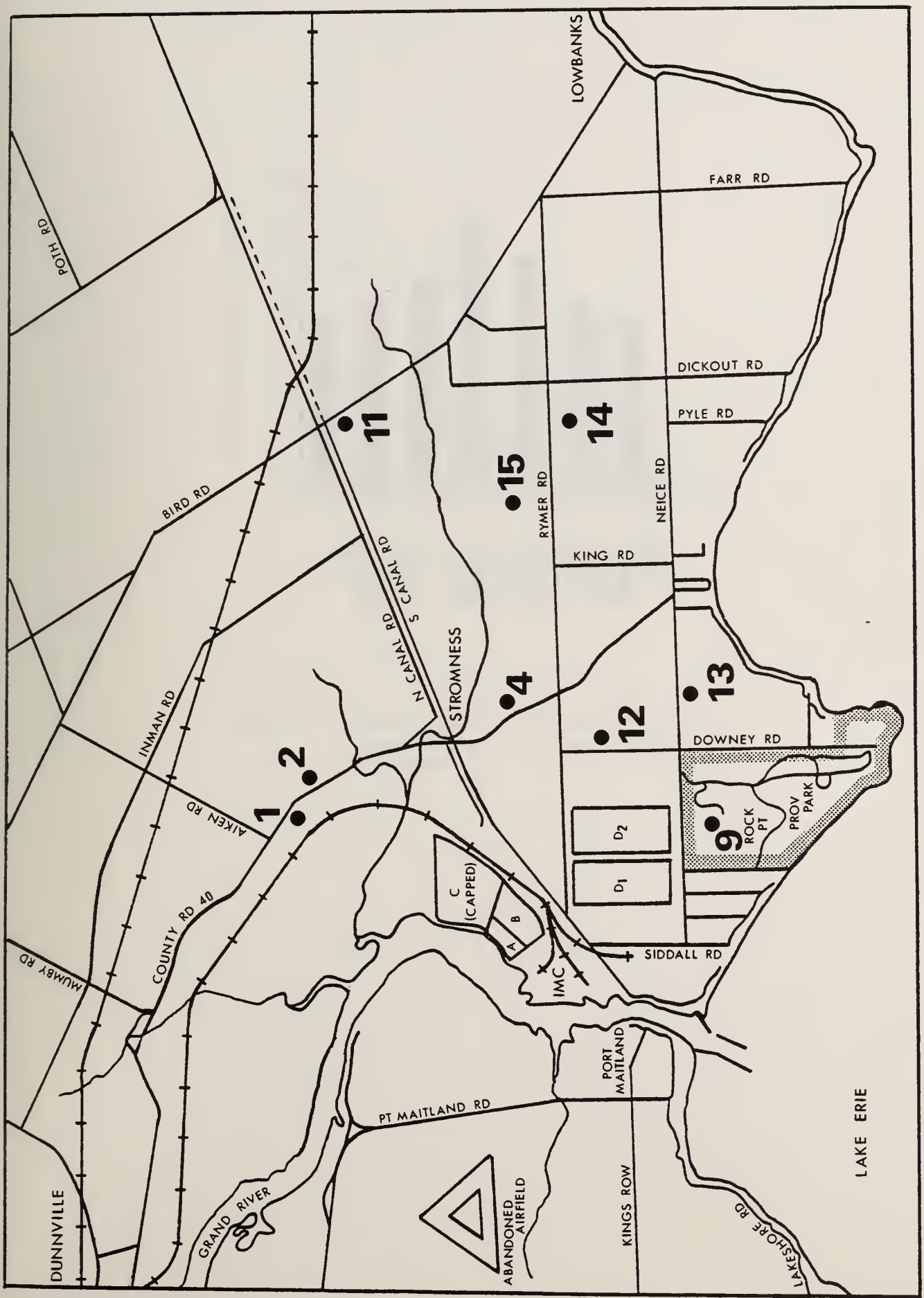
Foliar F levels in 1985 were the lowest since regular Phytotoxicology sampling was initiated in 1970. Although F and U concentrations in maple foliage were dramatically reduced in 1985 there was still a clear deposition gradient. Residual F

sources appear to be the D settling ponds and the area around the den. Foliar injury to sensitive plant species can still be observed in the immediate vicinity of these residual sources.

A soil survey conducted in 1985 revealed a clear F and U deposition gradient relative to the IMC manufacturing complex. The U soil concentration threshold level for growth/yield reductions for sensitive agricultural crops (50 ppm) is almost 10 times higher than the maximum and over 70 times greater than the average U value detected during the Port Maitland soil survey.

The IMC manufacturing site in Port Maitland, in its present non-operative condition, is not a significant source of air pollution. Unless otherwise instructed phytotoxicology activities will be continued at a reduced level in 1986 to gather additional post-shutdown data.

Figure 1. Location of Forage Collection Sites.



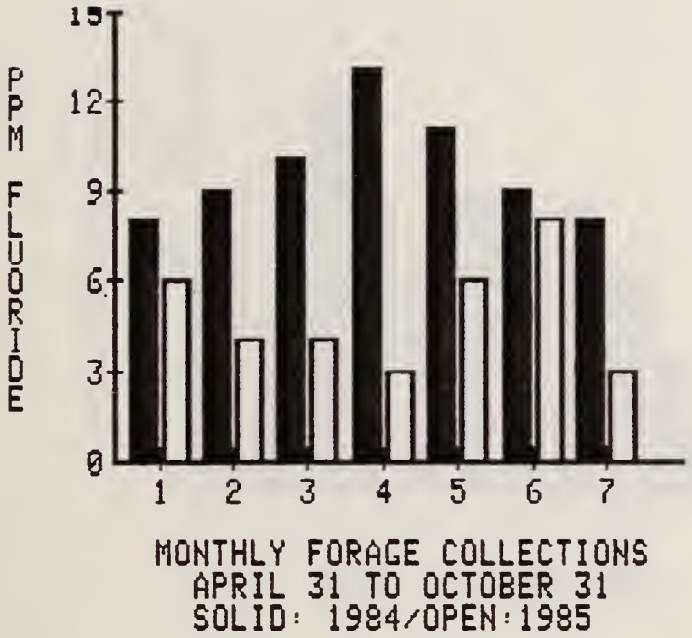


Figure 2. Mean (9 sites) Monthly Fluoride Concentration of Forage, 1984 and 1985.

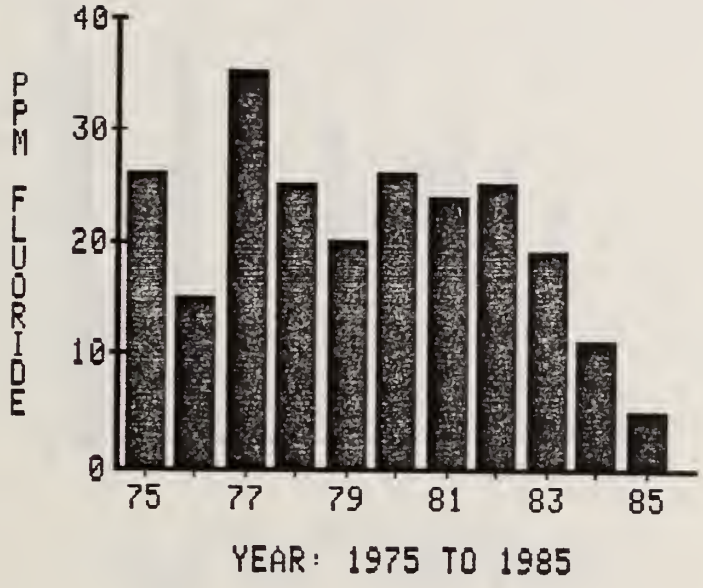


Figure 3. Growing Season Mean Fluoride Concentration of Forage, 1975 to 1985.

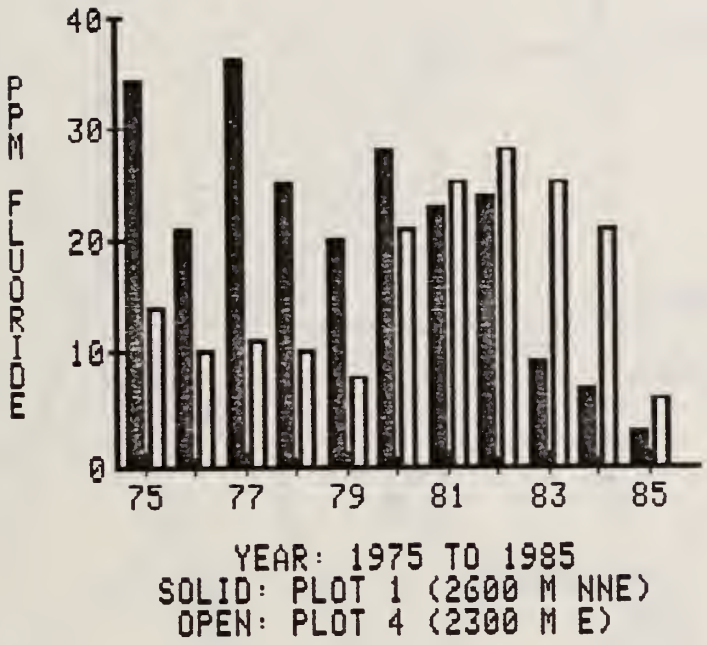


Figure 4. Growing Season Mean Fluoride Concentration of Forage at Sites 1 and 4, 1975 to 1985.

Figure 5. Growing Season Mean Fluoride Concentration of Forage, 1984 and 1985.

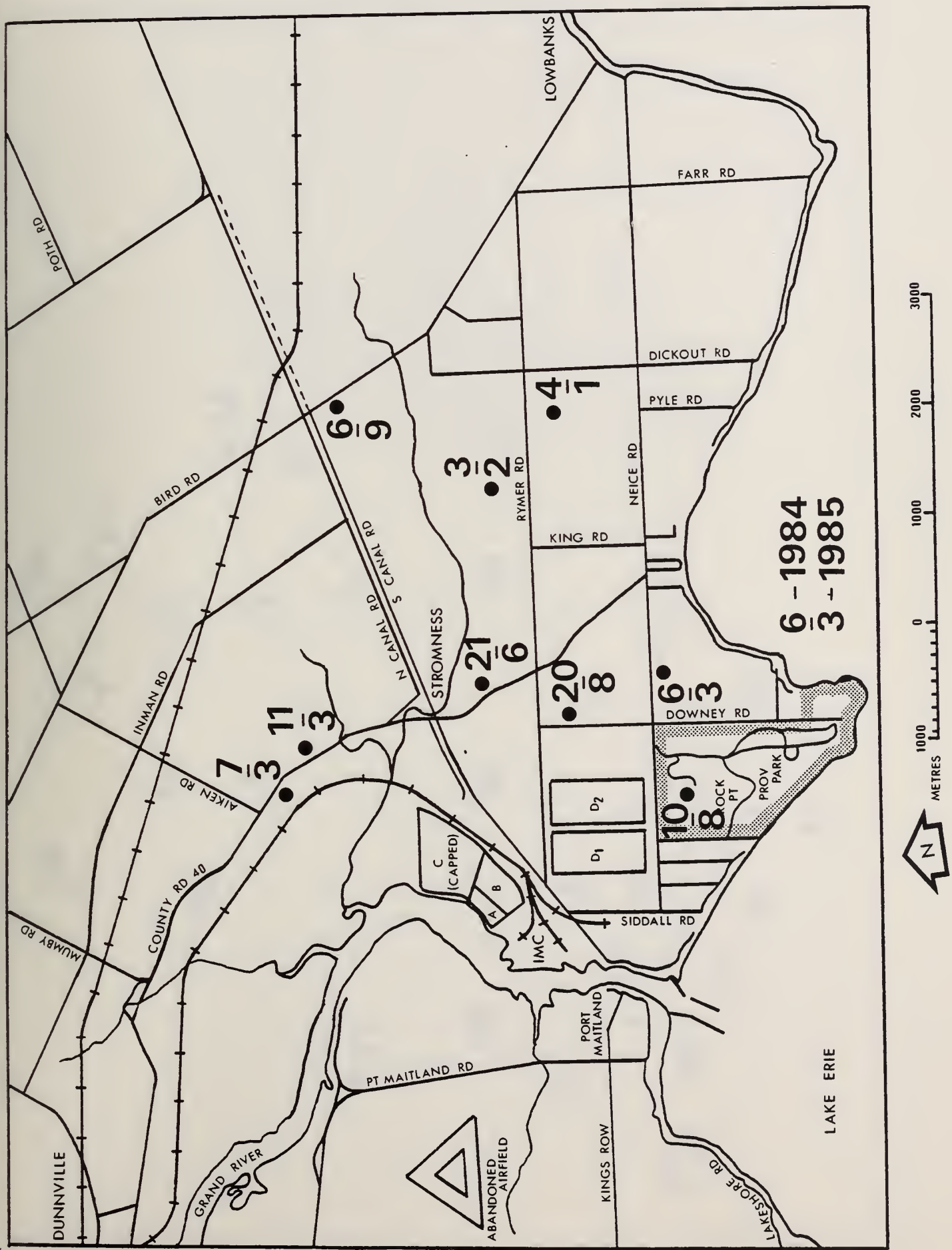
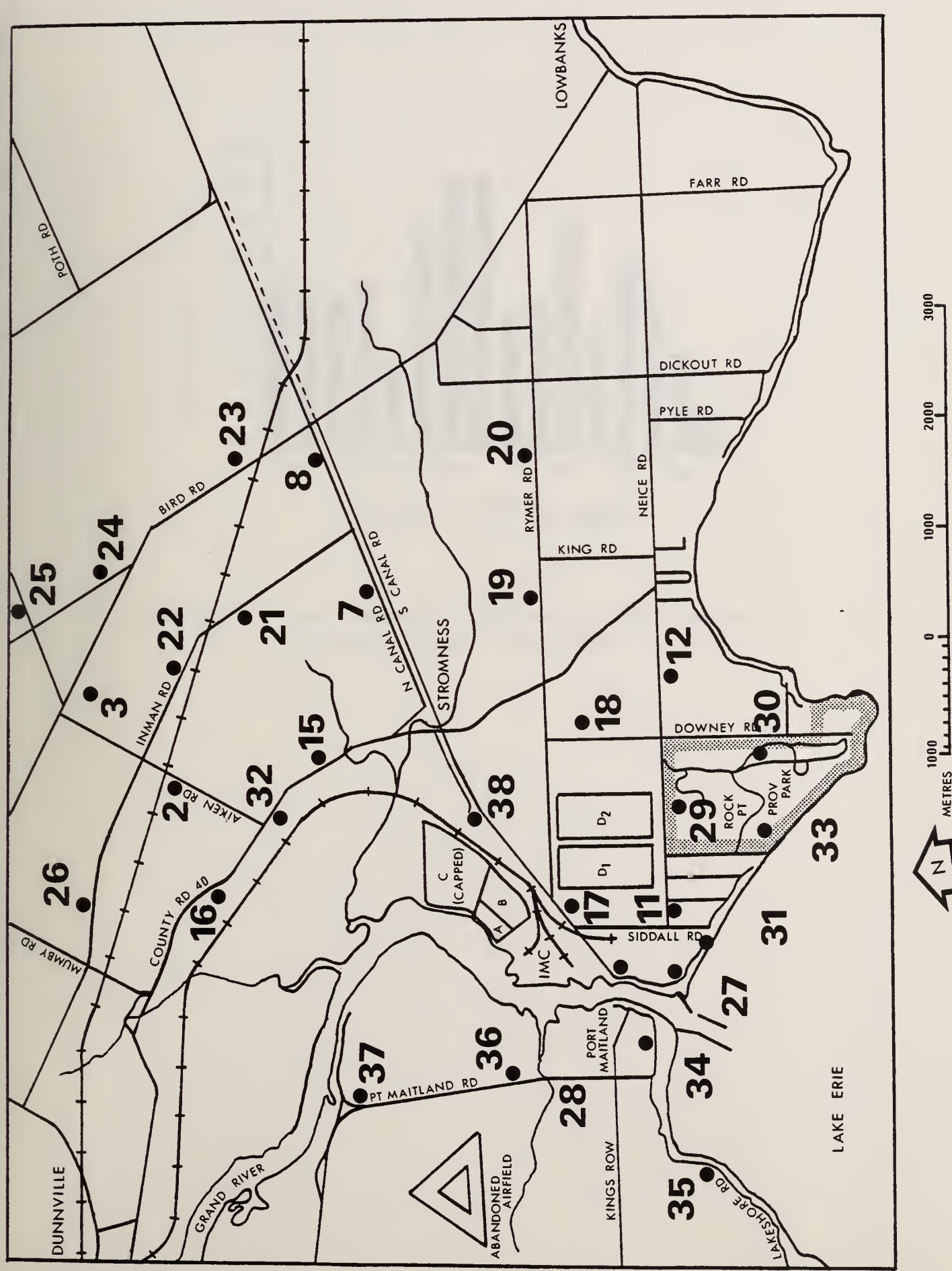


Figure 6. Location of Maple Foliage Collection Sites.



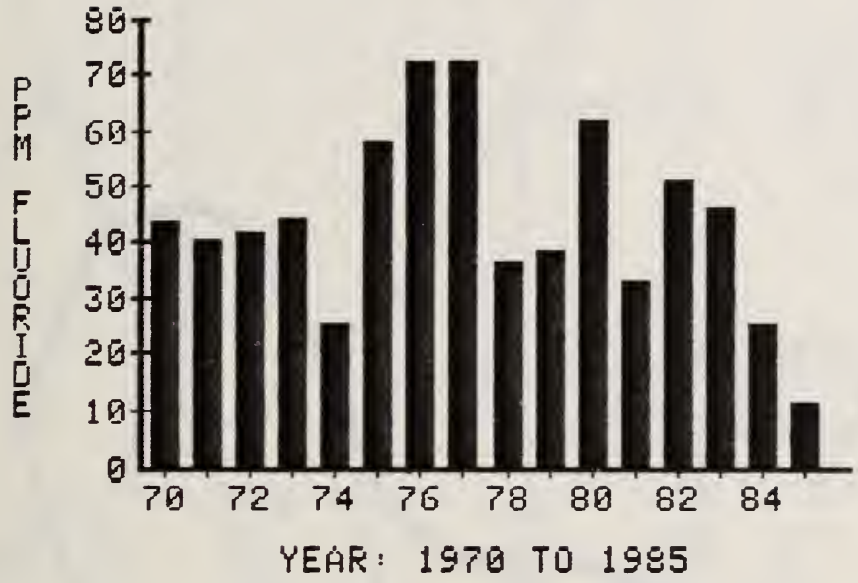


Figure 7 . Mean (common sites) Fluoride Concentration of Maple Foliage, 1970 to 1985.

Figure 8. Fluoride Concentration of Maple Foliage, 1983.

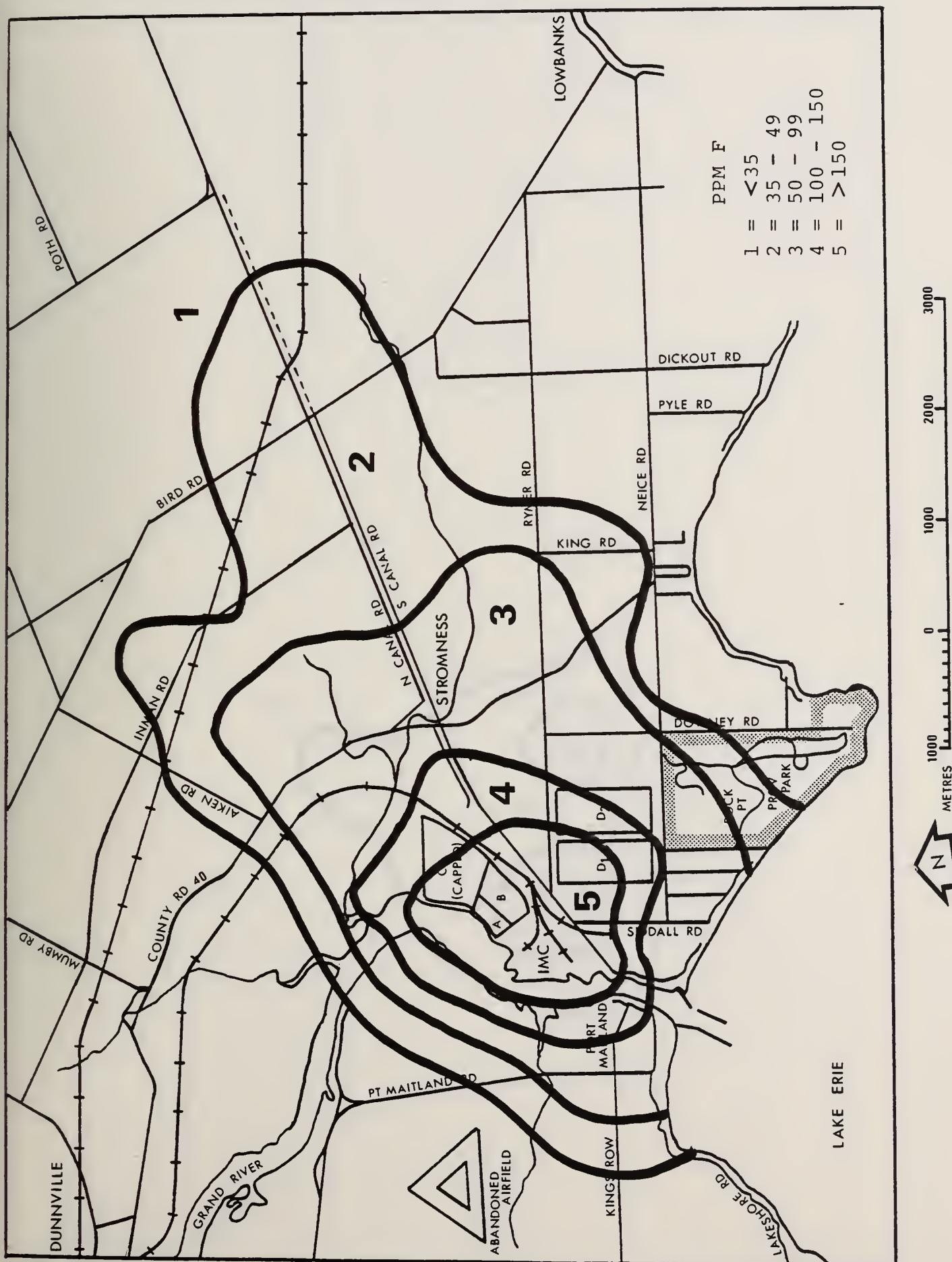


Figure 9. Fluoride Concentration of Maple Foliage, 1984.

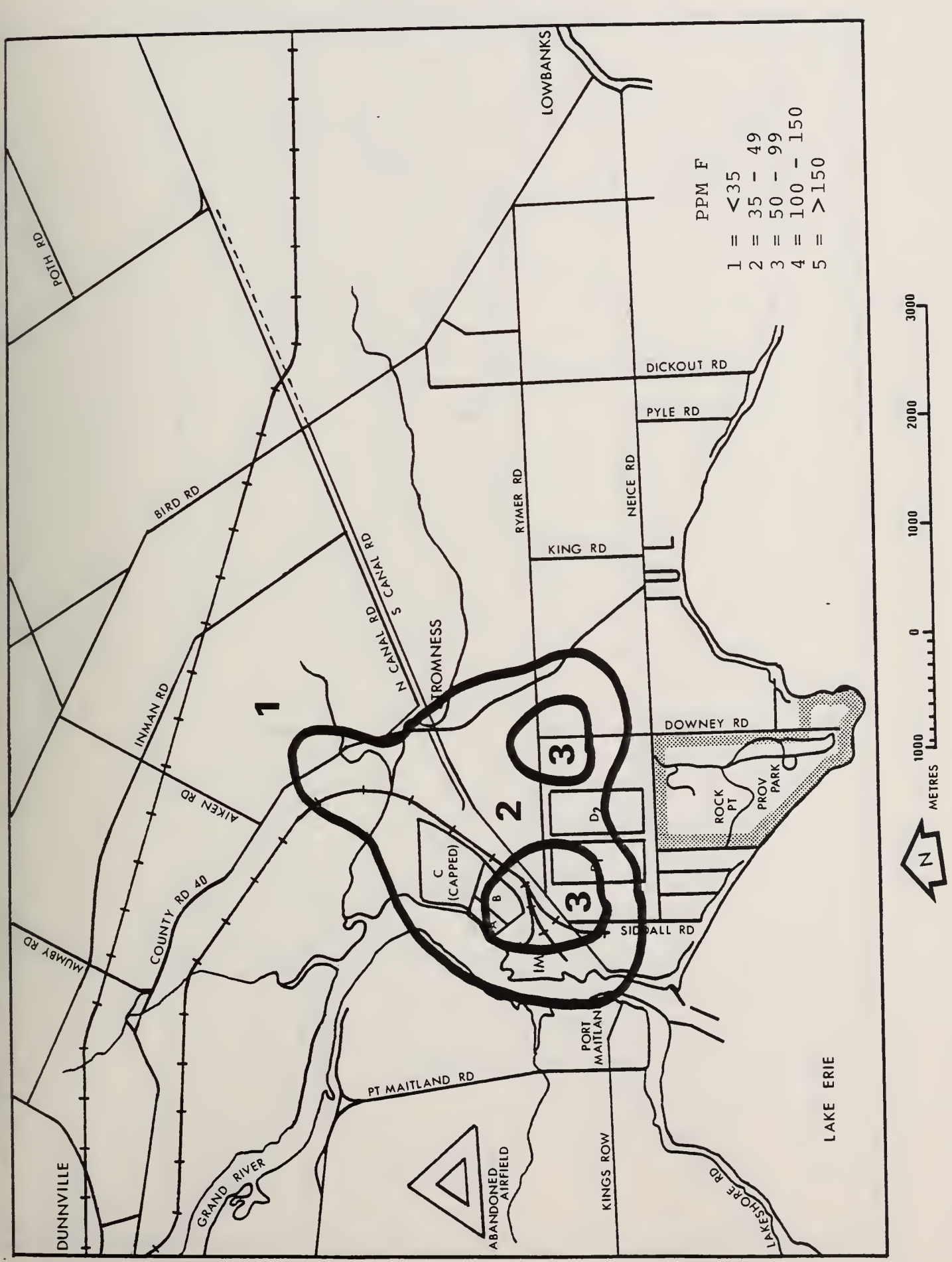


Figure10. Fluoride Concentration of Maple Foliage, 1985.

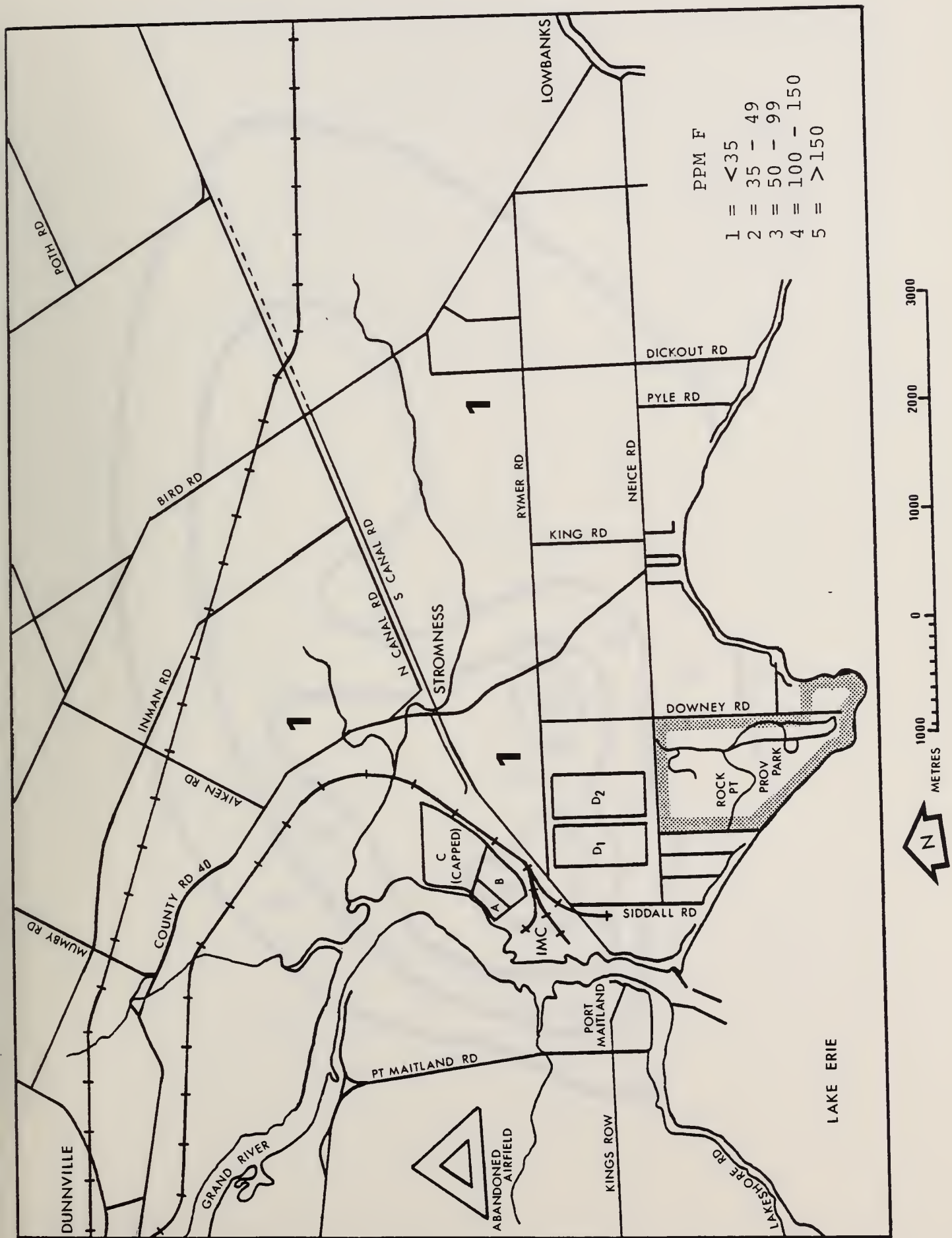


Figure 11. Fluoride Concentration of Maple Foliage, 1984.
LOWER VALUE RANGES

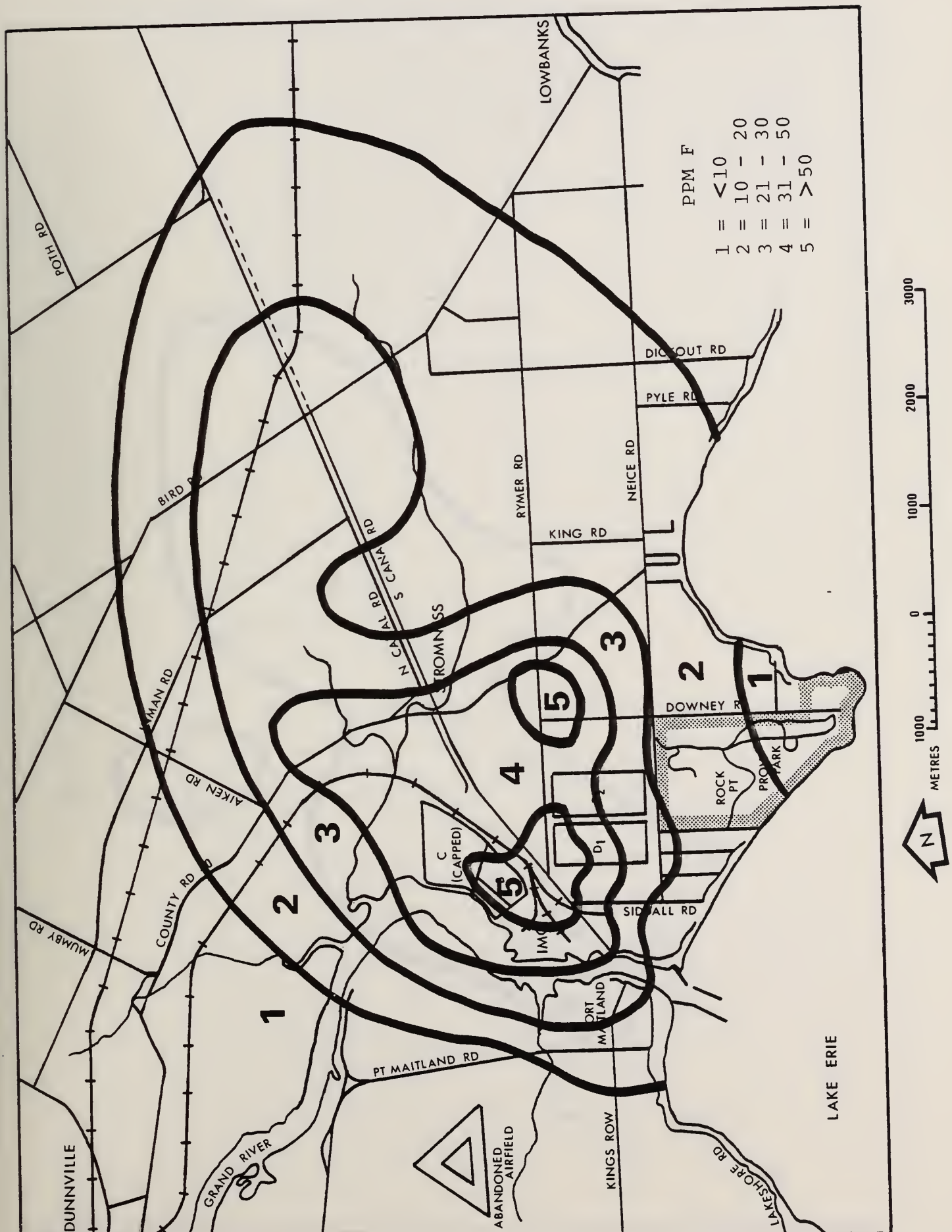


Figure 12. Fluoride Concentration of Maple Foliage, 1985.
LOWER VALUE RANGES

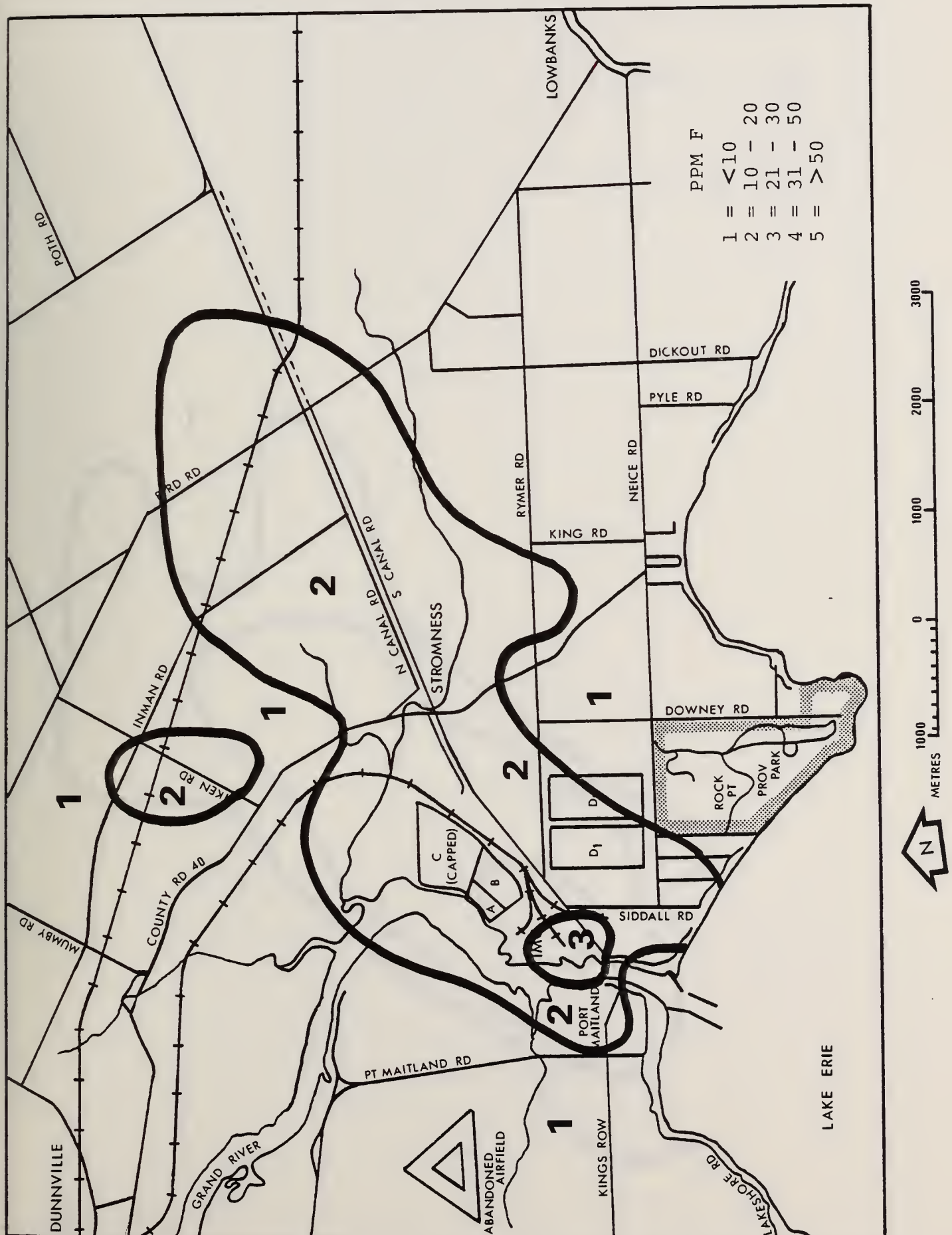


Figure 13. Uranium Concentration of Maple Foliage, 1983.

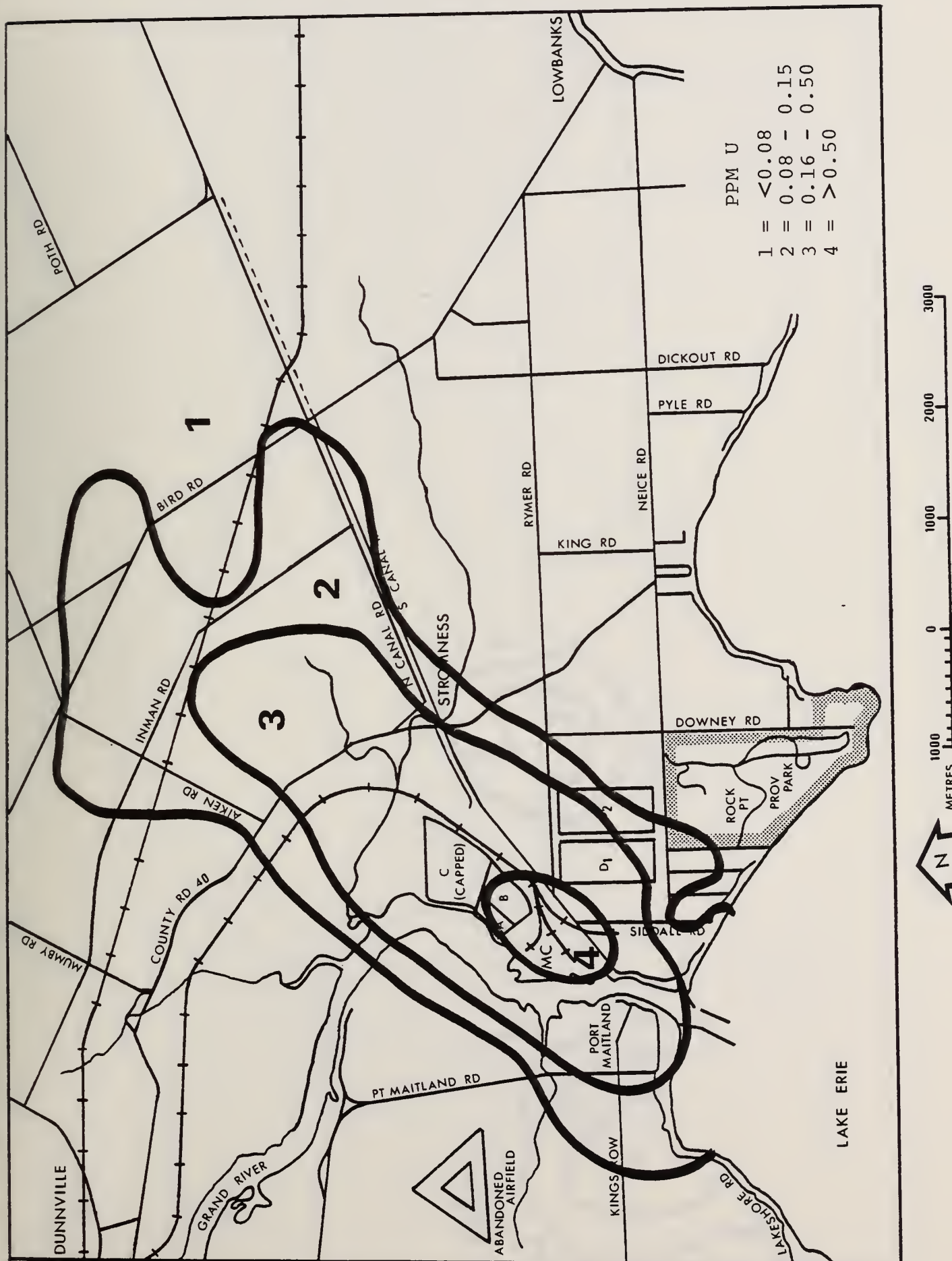


Figure 14. Uranium Concentration of Maple Foliage, 1985.

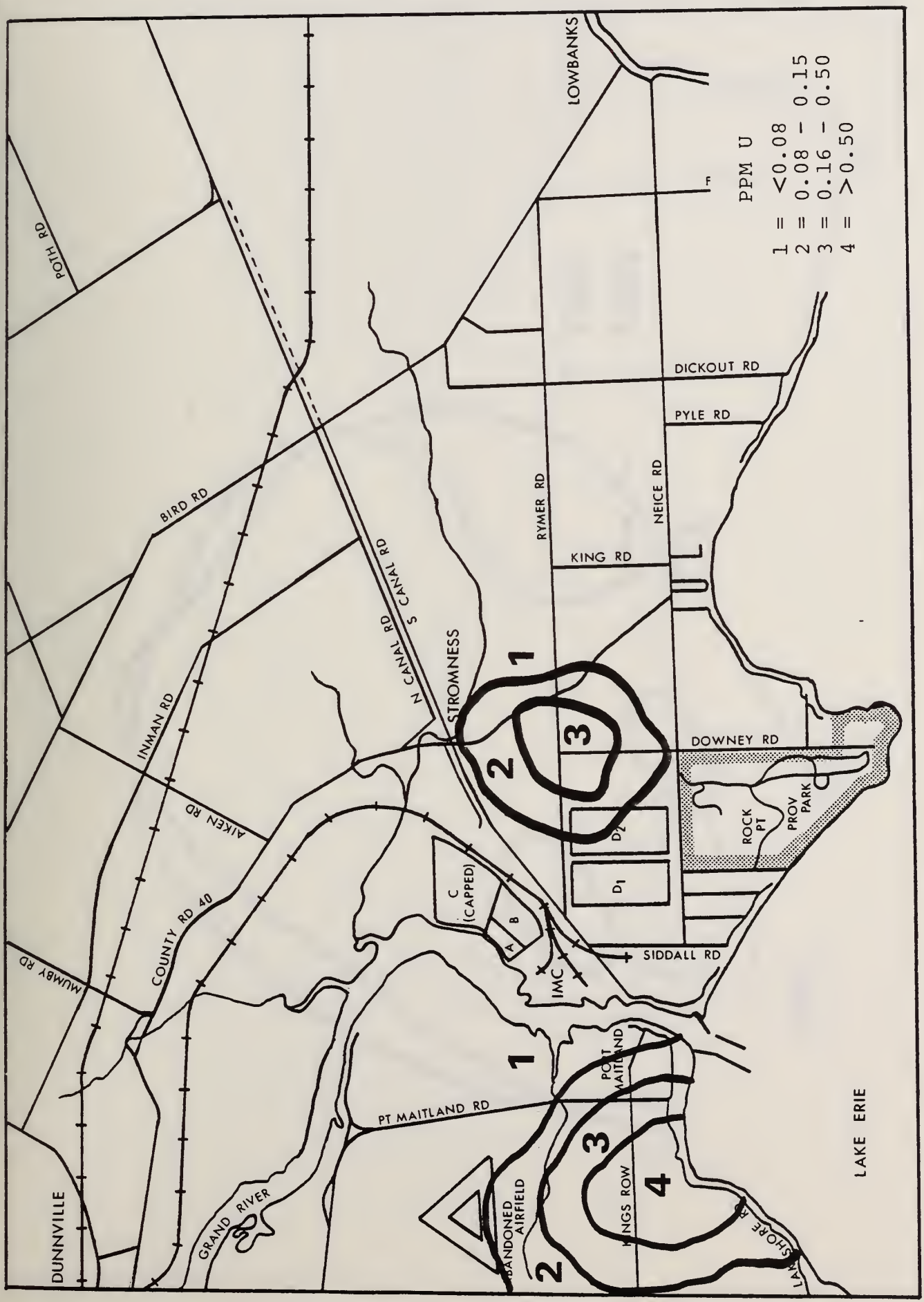


Figure 15. Extent of Fluoride Injury on Wild Grape Foliage.

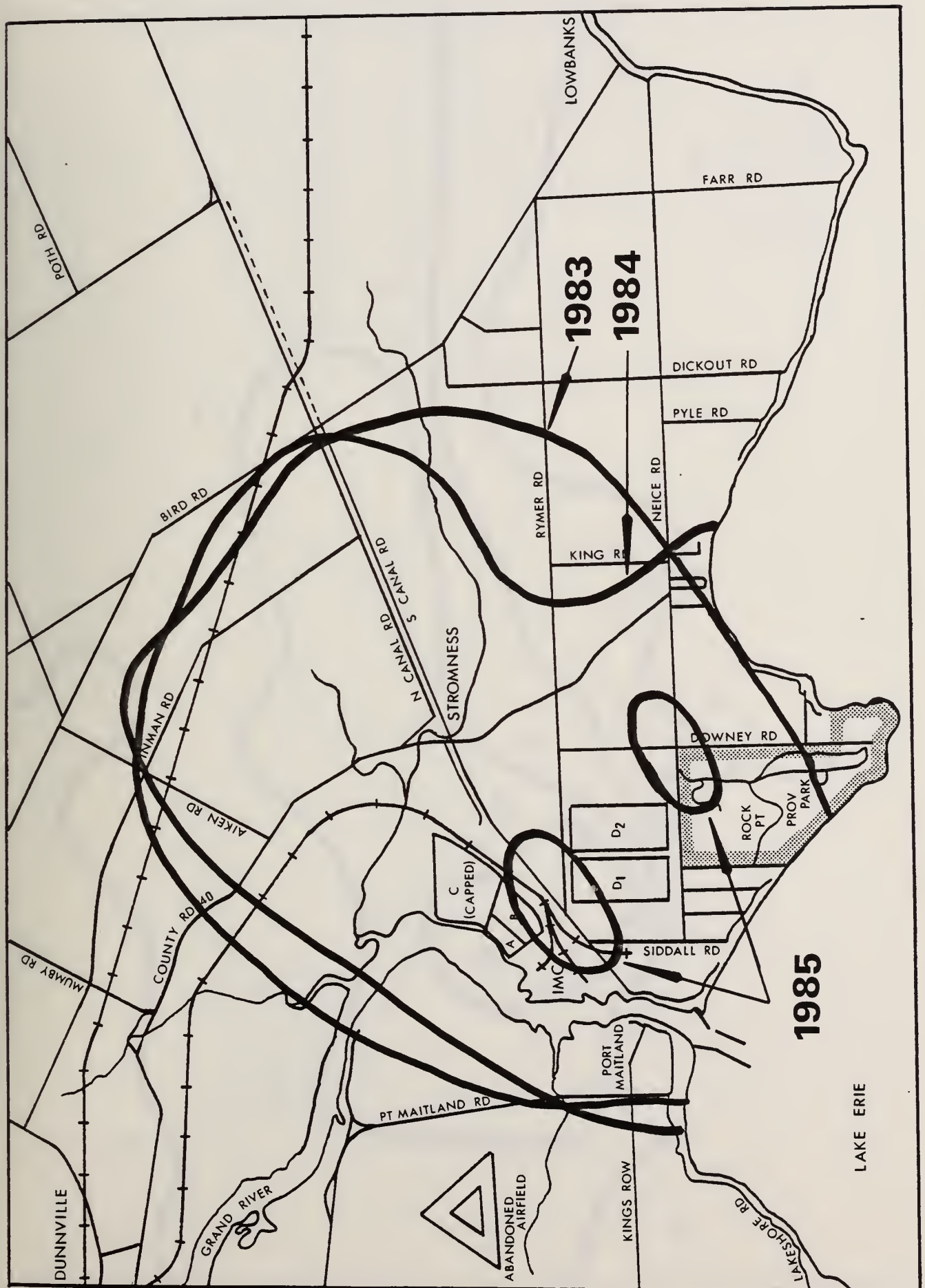


Figure 16. Fluoride Concentration of Surface Soil (0 to 5 cm), 1985.

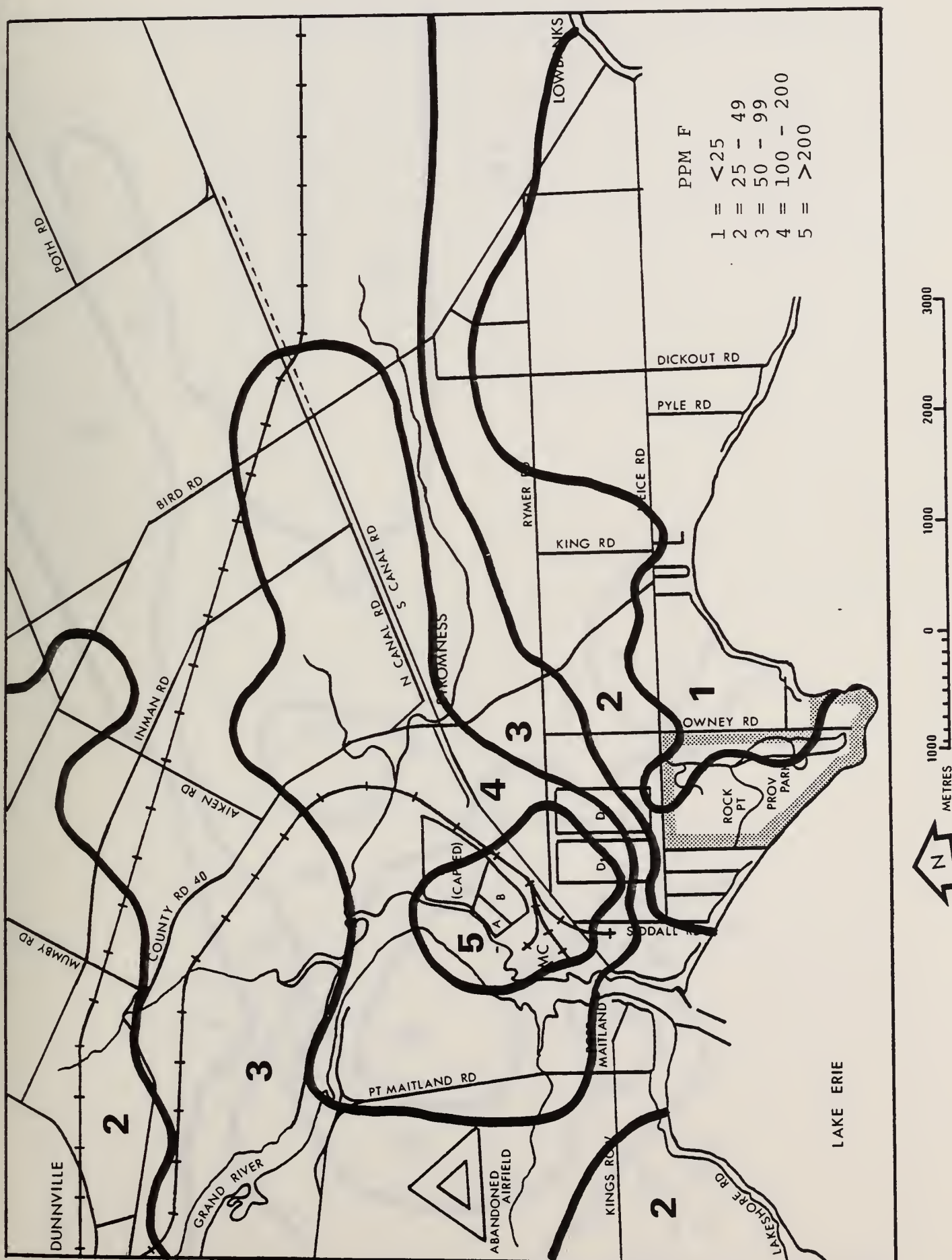


Figure 17. Uranium Concentration of Surface Soil (0 to 5 cm), 1985.

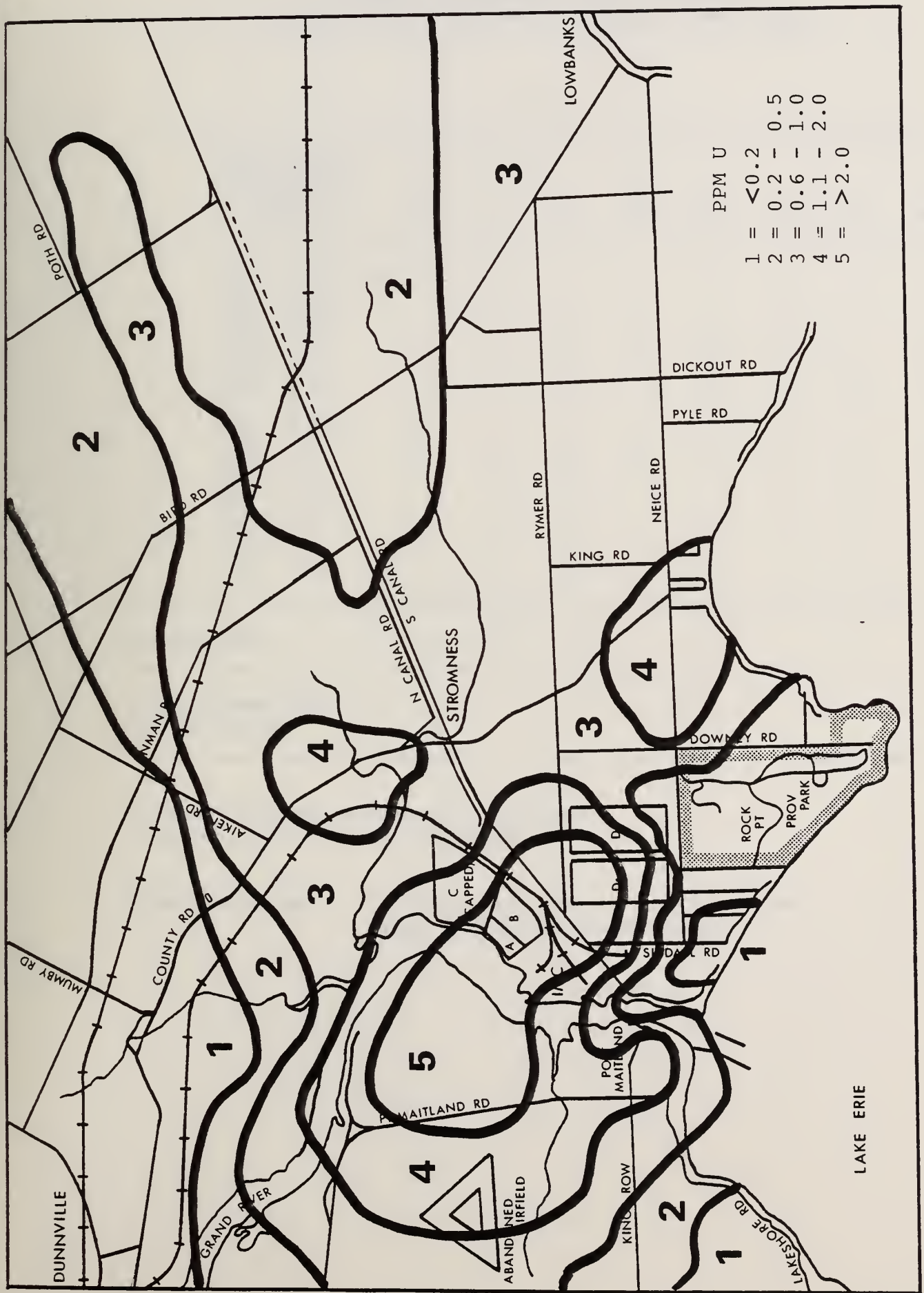


TABLE 1

FLUORIDE CONCENTRATION* OF FORAGE
DURING THE 1984 GROWING SEASON : PT MAITLAND

Site No.	Distance and Direction from IMC**		PPM F Apr.	May	June	July	Aug.	Sept.	Oct.	Mean
1	2600	M NNE	7	7	7	8	3	14	4	7
2	2600	M NE	7	14	13	15	6	16	5	11
4	2300	M E	17	13	24	40	24	15	11	21
9	1750	M SE	5	7	6	8	24	3	16	10
11	5050	M ENE	11	6	3	8	3	5	5	6
12	2050	M E	12	23	29	29	21	12	13	20
13	2500	M SE	8	3	5	7	8	2	8	6
14	4900	M E	4	5	2	3	3	9	4	4
15	4600	M E	5	2	2	2	5	5	2	3
Monthly Mean			8	9	10	13	11	9	8	10
Phytotoxicology Upper Limit of Normal						... 15 ...				

* Parts per million, not-washed, oven-dry basis
** Distance and direction from main stack

Criteria/Guideline: Single monthly sample not to exceed 80 ppm
Seasonal mean not to exceed 35 ppm

TABLE 2

1984 FORAGE SUMMARY : PT MAITLAND

Site No.	Distance and Direction from from IMC	Apr. - May	May - June	June - July	July - Aug.	Aug. - Sept.	Sept. - Oct.
1	2600 M NNE	7	7	8	6	9	9
2	2600 M NE	11	14	14	11	12	11
4	2300 M E	15	19	32	32	20	13
9	1750 M SE	6	7	7	16	14	10
11	5050 M ENE	8	5	6	6	4	5
12	2050 M E	18	26	29	25	17	13
13	2500 M SE	7	4	6	8	5	5
14	4900 M E	5	4	3	3	6	7
15	4600 M E	4	2	2	4	5	4

All values are ppm, not washed, oven-dried.

Guideline/Criteria: Not to exceed 60 ppm in any two consecutive monthly samples.

TABLE 3

FLUORIDE CONCENTRATION* OF FORAGE
DURING THE 1985 GROWING SEASON : PT MAITLAND

Site No.	Distance and Direction from IMC**		PPM F Apr.	May	June	July	Aug.	Sept.	Oct.	Mean
1	2600	M NNE	4	4	2	2	3	3	2	3
2	2600	M NE	5	3	3	3	2	4	3	3
4	2300	M E	8	7	4	4	7	9	4	6
9	1750	M SE	8	6	5	4	14	10	7	8
11	5050	M ENE	12	4	3	5	11	26	2	9
12	2050	M E	10	4	12	8	12	6	5	8
13	2500	M SE	5	3	2	2	3	1	3	3
14	4900	M E	3	2	<1	<1	<1	1	2	1
15	4600	M E	<1	2	<1	<1	<1	1	<1	2
Monthly Mean			6	4	4	3	6	8	3	5
Phytotoxicology Upper Limit of Normal						... 15 ...				

* Parts per million, not-washed, oven-dry basis
** Distance and direction from main stack

Criteria/Guideline: Single monthly sample not to exceed 80 ppm
Seasonal mean not to exceed 35 ppm

TABLE 4

1985 FORAGE SUMMARY : PT MAITLAND

Site No.	Distance and Direction from from IMC	Apr. - May	May - June	June - July	July - Aug.	Aug. - Sept.	Sept. - Oct.
1	2600 M NNE	4	3	2	3	3	3
2	2600 M NE	4	3	3	3	3	3
4	2300 M E	8	6	4	6	8	6
9	1750 M SE	7	6	5	9	12	9
11	5050 M ENE	8	3	4	8	19	14
12	2050 M E	7	8	10	10	9	6
13	2500 M SE	4	3	2	3	2	2
14	4900 M E	3	2	< 1	< 1	1	2
15	4600 M E	2	2	< 1	< 1	< 1	< 1

All values are ppm, not washed, oven-dried.

Guideline/Criteria: Not to exceed 60 ppm in any two consecutive monthly samples.

TABLE 5

NUMBER OF CONTROL ORDER VIOLATIONS* : PT MAITLAND
1975 - 1985

Year	No. of Violations: Criteria**			
	80	60	40/35	Total No.
1975	0	0	0	0
1976	0	0	0	0
1977	4	4	6	14
1978	0	0	3	3
1979	0	0	0	0
1980	2	4	4	10
1981	3	5	7	15
1982	0	0	2	2
1983	0	0	1	1
1984	0	0	0	0
1985	0	0	0	0

* Ministerial Control Order was officially suspended in 1980, however, sampling continued to monitor fluoride in forage.

** Up to 1982, Criteria were as follows:

- Not to exceed 80 ppm in two consecutive bi-weekly samples.
- Not to exceed 60 ppm in four consecutive bi-weekly samples.
- Not to exceed 40 ppm in eight consecutive bi-weekly samples.

After 1983, the Criteria were altered:

- Not to exceed 80 ppm for any single month.
- Not to exceed 60 ppm for two consecutive months.
- Not to exceed 35 ppm over the (7 month) growing season.

TABLE 6

FLUORIDE CONCENTRATION* OF MAPLE FOLIAGE : PT MAITLAND 1982 - 1985

Site No.	Distance and Direction from IMC**	PPM F 1982	1983	1984	1985
2	3.8 km NNE	30	28	10	14
3	4.8 km NNE	13	6	5	3
6(38)	1.4 km ENE	103	104	38	16
7	3.2 km ENE	82	46	18	14
8	5.1 km ESE	45	51	27	21
11	1.4 km ESE	70	82	21	10
12	2.7 km ESE	21	22	15	7
15	2.8 km NE	26	93	37	9
16	2.9 km NNE	10	15	6	6
17	0.5 km E	435	350	67	19
18	2.1 km ESE	96	84	56	9
19	3.4 km E	29	55	17	11
20	4.6 km E	19	21	12	8
21	4.3 km NE	24	32	26	16
22	4.4 km NE	43	48	13	7
23	5.4 km NE	24	33	19	16
24	5.5 km NE	18	16	20	7
25	6.0 km NE	9	15	9	5
26	4.3 km NE	16	8	6	4
27	0.8 km S	87	67	11	9
28	0.6 km S	400	160	34	26
29	1.8 km SE	120	65	15	9
30	2.5 km SE	22	22	7	6
31	1.6 km S	42	83	14	13
32	2.7 km NNE	11	31	16	10
33	3.3 km SSE	57	43	12	9
34	0.9 km SW	22	76	13	8
35	1.9 km SW	16	19	3	5
36	0.8 km WNW	6	18	7	4
37	1.7 km NW	12	15	15	ND
Mean		64	57	19	10
Phytotoxicology Upper Limit of Normal			... 35 ...		

* Parts per million, not-washed, oven-dry basis
** Distance and direction from main stack
ND No Data

TABLE 7

URANIUM CONCENTRATION* OF MAPLE FOLIAGE : PT MAITLAND
1981 - 1985

Site No.	Distance and Direction from IMC**	PPM F 1981	1982	1983	1984	1985
2	3.8 km NNE	.06	.10	.13	BD	BD
3	4.8 km NNE	BD	.08	BD	BD	BD
6(38)	1.4 km ENE	BD	.26	.24	BD	.05
7	3.2 km ENE	.06	.10	.11	BD	BD
8	5.1 km ESE	.05	.07	.09	BD	BD
11	1.4 km ESE	BD	.06	.15	BD	BD
12	2.7 km ESE	.06	.05	BD	BD	BD
15	2.8 km NE	.17	.11	.31	BD	BD
16	2.9 km NNE	BD	BD	BD	BD	BD
17	0.5 km E	.84	.45	.51	BD	BD
18	2.1 km ESE	BD	.11	BD	BD	.20
19	3.4 km E	BD	.05	BD	BD	BD
20	4.6 km E	BD	BD	BD	BD	BD
21	4.3 km NE	.06	.10	.07	BD	BD
22	4.4 km NE	.13	.09	.16	BD	BD
23	5.4 km NE	.08	BD	.08	BD	BD
24	5.5 km NE	.07	.09	.12	BD	BD
25	6.0 km NE	BD	BD	.06	BD	BD
26	4.3 km NE	BD	.07	BD	BD	BD
27	0.8 km S	.13	.10	.17	BD	BD
28	0.6 km S	.55	.46	.73	BD	BD
29	1.8 km SE	BD	.05	BD	BD	BD
30	2.5 km SE	BD	BD	.06	BD	BD
31	1.6 km S	BD	.08	.07	BD	BD
32	2.7 km NNE	.07	.08	.06	BD	BD
33	3.3 km SSE	BD	BD	BD	BD	BD
34	0.9 km SW	BD	.10	.18	BD	.06
35	1.9 km SW	BD	.06	.11	BD	.95
36	0.8 km WNW	BD	.06	BD	BD	.06
37	1.7 km NW	BD	.06	BD	BD	ND
Mean		.09	.10	.12	BD	.07

* Parts per million, not-washed, oven-dry basis
** Distance and direction from main stack
BD Below analytical detection limit (U = 0.05 ppm)
ND No Data

TABLE 8

FLUORIDE AND URANIUM CONCENTRATION*
OF SURFACE SOIL** : PT MAITLAND

1985

Site No.	Distance and Direction from IMC***	PPM F	PPM U
2	3.8 km NNE	90	BD
3	4.8 km NNE	15	BD
6(38)	1.4 km ENE	130	.83
7	3.2 km ENE	182	.50
8	5.1 km ESE	150	.39
11	1.4 km ESE	26	.30
12	2.7 km ESE	18	1.19
15	2.8 km NE	199	1.22
16	2.9 km NNE	71	.15
17	0.5 km E	523	5.34
18	2.1 km ESE	55	.91
19	3.4 km E	44	.80
20	4.6 km E	21	.54
21	4.3 km NE	56	.85
22	4.4 km NE	81	.61
23	5.4 km NE	148	.52
24	5.5 km NE	82	.28
25	6.0 km NE	102	BD
26	4.3 km NE	40	BD
27	0.8 km S	70	BD
28	0.6 km S	89	.22
29	1.8 km SE	23	.20
30	2.5 km SE	25	.20
31	1.6 km S	62	BD
32	2.7 km NNE	52	.93
33	3.3 km SSE	31	.34
34	0.9 km SW	66	1.18
35	1.9 km SW	40	.19
36	0.8 km WNW	134	2.16
37	1.7 km NW	ND	ND
Mean		89	.69

* Parts per million, not-washed, oven-dry basis
** Surface soil is 0 to 5 cm depth
*** Distance and direction from main stack
ND No Data
BD Below analytical detection limit (U = 0.10)

TABLE 9

MATRIX OF CORRELATION COEFFICIENTS OF SAMPLES COLLECTED FROM THE SAME 30 SAMPLES SITES : PT MAITLAND

	Soil F 1985	Soil U 1985	Foliar U 1981	Foliar U 1982	Foliar U 1983	Foliar U 1985	Foliar F 1982	Foliar F 1983	Foliar F 1984	Foliar F 1985
Soil F 1985		**.826** .0001 ***	**.771** .0001 ***	**.626** .0003 ***	**.552** .002 **	**.109** .574 NS	**.622** .0003 ***	**.793** .0001 ***	**.670** .0001 ***	**.453** .014 *
Soil U 1985	**.826** .0001 ***		**.702** .0001 ***	**.548** .002 **	**.395** .034 *	**.072** .709 NS	**.552** .002 **	**.762** .0001 ***	**.645** .0002 ***	**.229** .231 NS
Foliar U 1981	**.771** .0001 ***	**.702** .0001 ***		**.878** .0001 ***	**.848** .0001 ***	**.098** .615 NS	**.917** .0001 ***	**.887** .0001 ***	**.653** .0001 ***	**.567** .001 ***
Foliar U 1982	**.626** .0003 ***	**.548** .002 **	**.878** .0001 ***		**.913** .0001 ***	**.065** .739 NS	**.920** .0001 ***	**.844** .0001 ***	**.700** .0001 ***	**.671** .0001 ***
Foliar U 1983	**.552** .0002 **	**.395** .034 *	**.848** .0001 ***	**.913** .0001 ***		**.041** .831 NS	**.851** .0001 ***	**.763** .0001 ***	**.572** .001 ***	**.656** .0001 ***
Foliar U 1985	**.109** .574 NS	**.072** .709 NS	**.097** .615 NS	**.065** .739 NS	**.041** .831 NS		**.086** .656 NS	**.098** .661 NS	**.119** .540 NS	**.202** .294 NS
Foliar F 1982	**.622** .0003 ***	**.551** .002 **	**.917** .0001 ***	**.920** .0001 ***	**.851** .0001 ***	**.086** .656 NS		**.890** .0001 ***	**.684** .0001 ***	**.659** .0001 ***
Foliar F 1983	**.793** .0001 ***	**.762** .0001 ***	**.887** .0001 ***	**.844** .0001 ***	**.723** .0001 ***	**.098** .611 NS	**.890** .0001 ***		**.804** .0001 ***	**.581** .0009 ***
Foliar F 1984	**.670** .0001 ***	**.645** .0002 ***	**.653** .0001 ***	**.699** .0001 ***	**.572** .0001 ***	**.119** .540 NS	**.684** .0001 ***	**.804** .0001 ***		**.587** .0008 ***
Foliar F 1985	**.453** .014 *	**.229** .231 NS	**.567** .001 ***	**.671** .0001 ***	**.656** .0001 ***	**.202** .294 NS	**.659** .0001 ***	**.581** .0009 ***	**.587** .0008 ***	

.826 = correlation co-efficient
.0001 = p value
*** = *** p 0.001, ** p 0.01, * p 0.05, NS - not significant

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